J. Trop. Agric. and Fd. Sc. 33(1)(2005): 9–15

Efficacy of different inductants on the flowering, yield and fruit quality of Josapine pineapple on peat soil

(Efikasi beberapa bahan induksi terhadap pembungaan, hasil dan kualiti buah nanas Josapine di tanah gambut)

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Key words: *Ananas comosus*, pineapple hybrid, forcing, flowering response, hormoning, flower initiation

Abstract

Pineapple plants flower erratically. Therefore, it is important to induce the plants into producing flowers and fruits. Differential responses to flower induction have been reported when different chemical inductants were used. Pineapple grown on different environments may also response differently to flower induction.

The effect of six different treatments of chemical inductants on the flowering, yield and fruit qualities of pineapple fruits was studied on nine-month-old Josapine pineapple plants grown on deep peat soil. At 33 days after induction, plants induced with ethephon had significantly higher flowering percentages compared to those treated with alpha naphthalene acetic acid (ANA) and calcium carbide. At 40 days after induction, almost all plants treated with ethephon had flowered. Plants treated with ANA had 75% flowering while those treated with calcium carbide had 93% flowering. Plants treated with a mixture of ANA and ethephon had 91% flowering. The progression of flowering in each treatment followed different pattern throughout the eight days of observation.

The implication of the flowering as affected by the treatments was discussed in relation to the influence on the overall management of the harvested fruits. Results on fruit qualities indicated most of the parameters measured were not affected by the treatments applied. Only fruit diameters and the index of fruit ripeness during harvesting were significantly affected by the treatments. Estimated yield per hectare was significantly affected by the treatments. Plots treated with ethephon have significantly higher yield compared to those treated with ANA.

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Introduction

Pineapple plants (*Ananas comosus* [L.] Merr.) flower erratically. However, regulation of flowering is indispensable for the management of the crop production. The floral differentiation in pineapple and the economic necessity to shorten the production cycle meant that in the majority of cases, artificial flower induction must be carried out to ensure a high and uniform flowering. Differential responses to flower induction have been reported when different chemical inductants were used. Pineapples grown on different environments may also respond differently to flower induction.

Artificial flower induction in the commercial farms provides the freedom in the choice of harvesting time, fruit weight and also the shortening of harvest period. Responses of pineapple plants to artificial flower induction have been reported elsewhere (Clark and Kerns 1942; Randhawa et al. 1970; Wee 1970, 1971; Wee and Ng 1971; Dass et al. 1975; Rukayah 1983, 1987; Mohammed Selamat et al. 1995; Abdul Rahman 1996). The effectiveness of the inductants varies and is related to the cultivar, the environment and the dosage applied (Mohammed Selamat et al. 1995).

As far back as 1936, compressed acetylene gas, or a spray of calcium carbide solution (which generates acetylene) was employed to expediate uniform blooming. Some growers merely deposited calcium carbide in the crown of each plant to be dissolved by rain. A more advanced method is the use of the hormone, alpha naphthalene acetic acid (ANA), which induce formation of ethylene and to trigger the flowering (Morton 1987).

Josapine is a new pineapple hybrid released in 1996 by the Malaysian Agricultural Research and Development Institute (Chan and Lee 1996). Prior to its release, the variety was known as Hybrid A25-34 (Anon. 1996). It has a superior quality than the two existing popular table cultivars Mauritius and Sarawak especially in terms of sweetness and resistance to black heart disorder. Therefore Josapine is considered the most potential cultivar to replace the existing table pineapple cultivars. Currently there are about 500 hectares of the pineapple holdings being cultivated with this cultivar.

The standard practice of flower induction for Josapine is by the application of 50 ml/plant of the ethephon solution, containing 200 ppm of 2-chloroethylphosphonic acid and 4% urea at 9 months after planting. However, this inductant is not always available throughout the country, especially those areas outside the state of Johor. There are also reports by some farmers that other chemical inductants can also be used with a better result in terms of flowering percentages and fruit qualities. Based on the above situation, studies were conducted to investigate the performance of several chemical inductants for flower induction for Josapine, by quantifying the percentages of flowering, fruit yield and fruit qualities.

Materials and methods

The study was conducted at MARDI IPRS, Pontian, Johor, between 1 November 1997 and 7 December 1998. The experimental area was a typical deep peat soil with a pH of 3.4. Total area of the experimental site was 0.037 ha and the plot size was 3.74 m x 4.15 m. Geographically, the site was located at 1° 30' N and 103° 27' E and was 3.0 m above sea level. Randomized complete block design with six treatments and four blocks of replicates were used. The detail of the six treatments is as follows:

T1 = 50 ml of 200 ppm ethephon solution containing 4% urea
T2 = One ANA tablet containing 0.5 mg alpha naphthalene acetic acid
T3 = 50 ml calcium carbide solution containing 7 g a.i. per litre solution
T4 = One ANA tablet containing 0.5 mg alpha naphthalene acetic acid, followed by 50 ml 4.6 ppm ANA solution applied at flower emergence
T5 = 50 ml of 200 ppm ethephon solution containing 4% urea, followed by 50 ml 4.6 ppm ANA solution applied at flower emergence
T6 = 50 ml of solution containing 200 ppm ethephon, 10 ppm ANA and 4% urea.

Planting system used was the high density monocrop planting with distances of 75 cm x 55 cm x 25 cm giving a density of 61,508 plants/ha. Each plot was planted with 72 uniformly graded Josapine suckers. The plants were arranged in double rows of 12 plants per row. Fertilizer rates and application were based on the standard practices applied by MARDI for Josapine on peat soil (Chan and Lee 1996). The direct broadcasted fertilizer applied on the 3, 5 and 8 months after planting was made up from a mixture of 72 kg Ammonium Sulphate (AS), 1 kg Christmas Island Rock Phosphate (CIRP) and 27 kg Muriate of Potash (MOP) for every 100 kg of the mixture fertilizer. During each application, a 14 g of the mixture fertilizer was applied to every plant. Other cultural practices followed the recommended activity by Mohammed Selamat (1996b).

Treatments were applied into the heart of the plants in a dry morning between 7.30 a.m. and 8.30 a.m. to ensure rapid absorption. Flowering percentages were recorded from 33–40 days after the start of treatment. Flowering success was determined as the emergence of the red heart of the plant. At harvest, 124 days after treatments of flower induction, 10 fruits were taken randomly within the inner rows of each plot for the record of fresh weight (with and without crown). Total soluble solid (TSS) of the fruit juices was determined using a hand refractometer (0–32% Brix). Fruit acidity, measured in terms of percentage of citric acid equivalent, was recorded using the acid titration method. The acid titration followed the method described by Tay (1972). Fruit characteristics such as fruit length, diameter (¼ and ¾ from the fruit base), tapering ratio, skin colour, flesh colour and the sugar:acid ratio were also recorded.

Skin colour was scored according to the following criteria: 1 = dark purple , 2 = purple with some yellowing, 3 = 25% yellow, 4 = 50% yellow, 5 = 75% yellow and 6 = 100% yellow. Flesh colour was scored according to the criteria of 1 = whitish, 2 = white with some yellowing, 3 = more white than yellow, 4 = more yellow than white, 5 = yellow. Potential yield was computed using the formula: Y = % F X 61,508 X FW where Y= yield (with crown in kg), F = flowering percentages and FW = average of fresh weight of fruit with crown (kg).

Statistical analyses of the collected data were performed using AGRESTAT MARDI program. Significant difference between treatments was reported using the Duncan Multiple Range Test.

Results

Flowering percentages

There were significant differences between treatments *(Table 1)*. T1 was the best treatment in terms of flowering percentages. At 33 days after flower induction, T1 had 69.3% flowering success and reached 100% at 39 days after flower induction. Plants treated with ANA pills, in T2 and T4 had very low flowering percentages up to 35 days after treatment. At 35 days after treatment, T2 and T4 recorded flowering of only 6.45% and 5.95% respectively. In contrast, the other four treatments had reached more than 30%. The results also showed that T2 and T4 were the two treatments giving flowering percentages

Table 1. The effect of several inductants on the flowering percentages of Josapine pineapple grown on peat

Treatment	Flowering percentages, days after treatment							
	33	34	35	36	37	38	39	40
T1	69.25a	91.25a	98.60a	98.60a	98.60a	98.60a	100.00a	100.00a
T2	1.70c	3.44d	6.45d	17.28c	28.53c	35.50c	60.40d	74.64b
T3	30.80b	33.58c	45.55c	57.00b	64.50b	75.61b	79.80c	93.40a
T4	2.46c	3.84d	5.95d	18.91c	27.70c	34.35c	59.18d	67.23b
T5	74.15a	77.03b	78.45b	89.75a	91.53a	97.89a	97.89ab	99.30a
T6	29.03b	32.15c	33.90c	48.20d	53.66b	69.29b	83.85bc	91.30a

Values with the same letter in a column are not significantly different, based on DMRT (p >0.05)

Table 2. The effect of several inductants on the fruit weight, crown weight and potential yield of Josapine pineapple grown on peat, harvested 124 days after treatment

Treatment	Fruit wt. (kg)		Crown wt. (g)	Yield with crown (kg/ha)
	With crown	Without crown		
T1	1.43a	1.27a	158.00a	87,726a
T2	1.41a	1.28a	171.93a	64,950b
T3	1.41a	1.29a	157.83a	80,827ab
T4	1.53a	1.39a	182.50a	63,388b
T5	1.49a	1.35a	186.50a	90,894a
T6	1.56a	1.41a	181.50a	87,115a

Values with the same letter in a column are not significantly different, based on DMRT (p >0.05)

lower than 75% at 40 days after flower induction. Flowering was delayed in both treatments. Flowering percentages reached 50% only at 38 days after flower induction.

Fruit weight, crown and yield

Fruit weights with crown and without crown were not different significantly *(Table 2)*. Crown weight was also not affected by the treatments. Estimated yield per hectare was significantly different between treatments (p <0.05). Treatments T1, T3, T5 and T6 gave estimated yield of more than 80 t/ha, while plants in treatments T2 and T4 yielded 64.95 and 63.39 t/ha respectively.

Fruit characteristics

Fruit length and crown length were not affected by the treatments *(Table 3)*. The chemicals used during flower induction had influenced the diameter of the fruit. The tapering ratio of the fruit remained unaffected by the treatments.

Fruit qualities

All parameters except skin colour were shown to be insignificantly different (p >0.05) *(Table 4)*. The skin maturity index of T1 and T5 were insignificantly different, 124 days after flower induction. These were at 2.48 and 2.55 respectively.

Discussion

Chemical inductants such as ethephon, calcium carbide and naphthalene acetic acid have been widely used for commercial application in pineapple plantations (Clark and Kerns 1942; Cooper 1942; Randhawa et al. 1970; Dass et al. 1975; Mohammed Selamat et al. 1996a). The current studies focussing on the responses of Josapine hybrid pineapple to several flower inductants confirmed the capability and the

Table 3. The effect of several inductants on the fruit characteristics of Josapine pineapple grown on peat

Treatment	Fruit characteristics				
	L, cm	D_1, cm	D_2, cm	TR	CL, cm
T1	16.27a	11.99ab	11.24ab	0.94a	19.42a
T2	17.45a	11.56bc	10.74cd	0.93a	17.37a
T3	17.05a	11.33c	10.70d	0.95a	18.32a
T4	18.15a	11.90ab	10.90bcd	0.92a	18.67a
T5	16.94a	12.13a	11.43a	0.94a	19.19a
T6	17.88a	12.07a	11.20abc	0.93a	18.03a

Values with the same letter in a column are not significantly different, based on DMRT (p >0.05), L = Fruit length, D_1 = Fruit diameter 1/4 from fruit base, D_2 = Fruit diameter 3/4 from fruit base, TR = Tapering ratio and CL = Crown length

Table 4. The effect of several inductants on the fruit quality of Josapine pineapple grown on peat

Treatment	Skin colour	Flesh colour	Total soluble solid content, % Brix)	Acidity, % Citric acid equivalent	Sugar: acid ratio
T1	2.48 a	4.28 a	14.88 a	0.77 a	19.33 a
T2	1.20 bc	3.30 a	14.08 a	0.79 a	17.92 a
T3	1.64 bc	3.69 a	14.48 a	0.80 a	18.58 a
T4	0.99 c	3.73 a	13.81 a	0.82 a	16.93 a
T5	2.55 a	4.00 a	14.71 a	0.74 a	19.89 a
T6	1.85 ab	3.93 a	14.46 a	0.76 a	18.08 a

Values with the same letter in a column are not significantly different, based on DMRT(p >0.05)

efficiency of the chemical tested for this new cultivar. The red heart emergence in the cultivar Josapine was faster with the application of ethephon. The results of the current study showed that the flowering pattern within each inductant was different within the period of 8 days of observation from the 33–40 days after induction.

The standard practice of using 200 ppm ethephon and 4% urea (T1) was found to be the best inductant in the current study. T1 had 100% flowering and the red heart appearance was also faster compared to the rest of the treatments. T1 and T5 had the highest flowering percentages at 33 days after induction. At that period, the flowering percentages of the two treatments were already above 65%, whereas the treatments were still below 35% level. Adding ANA to ethephon as shown in T6 had resulted in significantly very low flowering percentage at 33 days after the treatment.

Except for the fruit diameter and the skin colour at harvest, the rest of the fruit qualities of Josapine were not affected by the inductants tested. In a study on mineral soil, Abdul Rahman (1996) reported that calcium carbide applied with the same rate as in the current study resulted in the lowest flowering percentages as compared with ethephon and ANA. He reported a flowering percentage of 58.8% with calcium carbide, 6 weeks after induction (42 days). The current study however, indicated that plot treated with calcium carbide had the flowering of 93.4% at 40 days after induction. Perhaps the difference was because of the different cultivar used (Mauritius). The non-significant differences for the fruit qualities showed that the type of

flower inductants did not influence the fruit quality of Josapine. Therefore, the growers could choose their inductants from the available ones in the market.

Etephon as applied in the current study had given a higher and faster flowering percentages compared with ANA and calcium carbide. A similar result was reported in India by Dass et al. (1975) for the pineapple of Kew cultivar. Therefore the results had again confirmed the widely claimed fact that ethephon is the best inductant for pineapple flowering.

Since there was a significant difference between treatments in terms of flowering percentages at 40 days after flower induction, the estimated yield followed a similar effect. This study indicated that yield per hectare was higher with plants treated by ethephon. The average fruit weight of 1.47 kg with crown and 1.33 kg without crown obtained in this study fell within the ranges of earlier study involving the use of ethephon for Josapine (Anon. 1996).

Differences in the estimated yield reported in this study were due to the flowering percentages. Additional yield may be harvested from those plants forced later, 40 days after the first flower induction. Therefore a result with faster and higher flowering percentages is the prerequisite of a higher productivity. Although calcium carbide and ANA yielded a lower tonnage and slower flowering progress, it is still a good alternative to ethephon when ethephon is not available for use.

Conclusion

At 30 days after treatment, Josapine pineapple plants induced with ethephon had significantly higher flowering percentages compared with alpha naphthalene acetic acid (ANA) and calcium carbide. At 40 days after induction, almost all plants treated with ethephon had flowered. Plants with ANA were 75% flowered while those treated with calcium carbide had 93% flowering. The progression of flowering in each treatment followed different patterns throughout the eight days period of observation. The implication of the flowering as affected by the treatments was discussed in relation to the influence of the overall management of the harvested fruits. Results on fruit quality indicated by the parameters measured were not affected by the treatments. Estimated yield per hectare was significantly affected by the treatments. Plots treated with ethephon have significantly higher yield compared to those treated with ANA.

Acknowledgement

This study was funded by IRPA (Research Grant No. HR-02-02-01).

References

Abdul Rahman, H. (1996). Kesan beberapa kimia aruhan ke atas pembungaan nanas Moris di atas tanah mineral. *Proc. of the Seminar on the Fruit Industry in Malaysia*, 7–9 Sept., 1993, Johor Bahru, p. 225–8. Kuala Lumpur: MARDI

Anon. (1996). MARDI memperkenalkan varieti baru nanas HIBRID A 25–34. Edaran maklumat pelancaran baka nanas baru MARDI (dinamakan Josapine kemudiannya). Serdang: MARDI

Chan, Y.K., and Lee, H.K. (1996). 'Josapine': a new pineapple hybrid developed at MARDI. *Proc. 2nd National Congress on Genetics*. 13–15 Nov. 1996, Kuala Lumpur, (Mohamad, O., Mahani, M.C. and Zulkeflie, Z., ed.) p. 217–20. Kuala Lumpur: Genetic Soc. Malaysia

Clark, H.E. and Kerns, K.R. (1942). Control of flowering with phytohormones. *Science 95*: 1536

Cooper, W.C. (1942). Effect of growth substances on flowering of pineapple under Florida conditions. *Proc. of the American Society of Horticultural Science 41:* 93–8

Dass, H.C., Randhawa, G.S. and Negi, S.P. (1975). Flowering in pineapple as influenced by ethephon and its combination with urea and calcium carbonate. *Scientia Horticulturae 3:* 231–8

Mohammed Selamat, M. (1996a). Kesan saiz bahan tanaman terhadap tumbesaran dan hasil nanas kaleng kv. Gandul di atas tanah gambut. *Proc. of the Seminar on the Fruit Industry in Malaysia*, 7–9 Sept. 1993, Johor Bahru, (Mohamed, M.S. Ahmad Tarmzi, S. &

Pauziah, M., ed.) p. 263–269. Serdang: MARDI

—— (1996b). *Penanaman nanas: nanas makan segar dan nanas kaleng*. 90 hlm. Serdang: MARDI

Mohammed Selamat, M., Masaud, R., Zahariah, M.N. and Md. Noor, Y. (1995). Peranan bahan aruhan pembungaan dalam meningkatkan hasil dan kualiti buah nanas segar. *Prosiding Seminar Industri Nanas '95,* Sarawak, (Mohammed Selamat, M., Roslan, A., Rosli, H. and Suhaila, Z). p. 162–72. Johor Bahru: LPNM (Lembaga Perindustrian Nanas Malaysia)

Morton, J. (1987). Pineapple. In: *Fruits of warm climates*. p. 18–28. Julia F. Morton. Miami, Florida, USA

Randhawa, G.S., Dass, H.C. and Chacko, E.K. (1970). Effect of ethrel, NAA and NAD on the induction of flowering in pineapple (*Ananas comosus* L.). *Current Science 39:* 530–1

Rukayah, A. (1983). Kajian aruhan pembungaan ke atas nanas Sarawak. *Teknol. Pertanian MARDI 4(1):* 58–63

—— (1987). Meninggikan hasil nanas Sarawak melalui aruhan kimia. *Teknol. Buah-buahan MARDI 3:* 31–4

Tay, T.H. (1972). Comparative study of the different types of fertilizers as sources of nitrogen, phosphorus and potassium in pineapple cultivation. *Trop. Agric. (Trinidad). 49:* 51–9

Wee, Y.C. (1970). The development of pineapple cultivation in West Malaysia. *Journal of Tropical Geography 30:* 68–75

—— (1971). The effect of Planofix on the pineapple fruit. *Malayan Pineapple 1:* 35–9

Wee, Y.C. and Ng, J.C. (1971). The effect of ethrel on the Singapore Spanish pineapple cultivation. *Malayan Pineapple 1:* 5–10

Abstrak

Pokok nanas berbunga secara tidak menentu dalam keadaan semula jadi. Oleh itu, ia perlu diaruh untuk menghasilkan bunga dan buah. Rangsangan terhadap bahan kimia aruhan pembungaan adalah berbeza mengikut jenis bahan kimia dan baka pokok nanas. Dalam persekitaran yang berbeza, rangsangan terhadap kimia aruhan pembungaan pada baka yang sama juga didapati boleh berbeza.

Kesan berbagai-bagai bahan kimia aruhan pembungaan terhadap peratus pembungaan, hasil dan kualiti buah nanas Josapine telah dikaji di Pontian, Johor. Kajian dijalankan pada pokok nanas Josapine yang berumur 9 bulan di tanah gambut dengan enam rawatan kimia aruhan. Tiga puluh tiga hari selepas aruhan, pokok yang diaruh dengan ethephon mempunyai peratus pembungaan yang tinggi dengan perbezaan yang bererti ($p < 0.05$) berbanding dengan pokok yang diberikan rawatan dengan asid asetik naftalena alfa (ANA) atau kalsium karbida. Empat puluh hari selepas aruhan, kesemua pokok yang disembur dengan ethephon telah berbunga. Pokok yang dirawat dengan ANA berbunga 75% manakala yang dirawat dengan kalsium karbida berbunga 93%. Pokok yang diberikan rawatan campuran ANA dengan ethephon memberikan 91% pembungaan. Perkembangan pembungaan bagi setiap rawatan diikuti selama 8 hari.

Implikasi pembungaan yang dipengaruhi oleh rawatan telah dibincangkan dari segi kaitannya dengan kesan terhadap pengurusan umum buah-buah yang akan dituai. Keputusan berkaitan kualiti buah menunjukkan bahawa kebanyakan parameter yang diukur tidak dipengaruhi oleh rawatan yang diberikan. Hanya garis pusat buah dan indeks kematangan buah ketika penuaian yang dipengaruhi oleh rawatan. Anggaran hasil sehektar dipengaruhi oleh rawatan yang diberikan. Petak yang dirawat dengan ethephon memberikan hasil yang lebih tinggi berbanding rawatan dengan ANA.

Accepted for publication on 25 August 2004